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NATURAL ENVIRONMENT DESIGN REQUIREMENTS FOR THE SPACELAB

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16. ABSTRACT

This report presents the natural environment design requirements for the Spacelab. Because the Spacelab is to be carried as "cargo" to orbital altitudes in the Space Shuttle bay, orbital environment impacts are the main concern of the report.

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NATURAL ENVIRONMENT DESIGN REQUIREMENTS FOR THE SPACELAB

1.0 PURPOSE AND SCOPE

The definition of natural environment design requirements for Spacelab missions.

2.0 NATURAL ENVIRONMENT — GENERAL

The natural environment criteria given in this report are consistent with those specified for the Space Shuttle system and will be used for the design of the Spacelab with respect to radiation, atmospheric characteristics at orbital altitudes, and other pertinent natural environment requirements. Design value requirements of natural environment parameters not specifically defined herein will be obtained from NASA TM X-64757, Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development, 1973 Revision, 1973 [1], and NASA TM X-64627, Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development, 1971 Revision, November 15, 1971 [2]. The Spacelab will be subject to environmental factors peculiar to the Space Shuttle during assembly, checkout, launch, and attainment of orbital positioning prior to removal of the Spacelab from the Shuttle bay; therefore, appropriate Shuttle documents should be consulted when the Spacelab is "cargo" in the Space Shuttle.

Natural environmental data required in design or mission analyses for the Spacelab and not contained in the previously cited documents will be requested from or approved by the Aerospace Environment Division, Space Sciences Laboratory, Marshall Space Flight Center, through the cognizant NASA Contract Representative prior to use.

3.0 NEUTRAL ATMOSPHERE — ORBITAL ALTITUDES

3.1 The Jacchia 1970 Model Atmosphere will be used. See Appendix B of NASA TM X-64627 for details.

3.2 The design steady state values of the orbital neutral atmospheric gas properties shall be calculated using a value of 230 for the mean 10.7 cm solar flux and a geomagnetic index (a_p) of 20.3 with a local time of day of 0900 hr as inputs to the Jacchia 1970 Model Atmosphere.

3.3 The design short-time extreme values of the atmospheric gas properties shall be calculated using a value of 230 for the mean 10.7 cm solar flux, a geomagnetic index (a_p) value of 400, and a local time of day of 1400 hr as inputs to the Jacchia 1970 Model Atmosphere. These orbital neutral atmospheric gas property values represent an estimate of the conditions that may occur for a short period of time (12 to 36 hours) during an extremely large magnetic storm.

3.4 Exosphere (37,000 km Geosynchronous Orbital Altitude). The data given in Section 2.2.2 of NASA TM X-64627 shall be used.

4.0 CHARGED PARTICLES

The electron density values and data in Section 2.3 of NASA TM X-64627 shall be used.

5.0 RADIATION

In addition to the following, use Section 2.4 of NASA TM X-64627. The Spacelab shall be designed to provide the necessary protection to insure that the safe dosage limits for the equipment and crew are not exceeded.

5.1 Galactic Cosmic Radiation. Galactic cosmic radiation consists of low-intensity, extremely high-energy charged particles. These particles (approximately 85 percent protons, 13 percent alphas, and the remainder heavier nuclei) bombard the solar system from all directions. They have energies from 10^8 to 10^{19} electron volts (eV) per particle and are encountered essentially everywhere in space. The intensity of this environment in free space (e.g., outside the influence of the Earth's magnetic field) is relatively constant (0.2 to 0.4 particles per square centimeter per steradian per second) except during periods of enhanced solar activity when the fluxes of cosmic rays have been observed to decrease due to an increase in the strength of the interplanetary magnetic field which acts as a shield to incoming particles. Near the Earth, cosmic rays are similarly influenced by the Earth's magnetic field, resulting in a spatial variation in their intensity. The extreme of the galactic cosmic ray environment is at sunspot minimum. The environment is constant and may be scaled down to 24 hours. See Section 2.4.1 of NASA TM X-64627 for additional data on this subject.

Estimates of the daily cosmic ray dose behind 1 g/cm^2 aluminum shielding for the various orbits are shown in Table 1. These estimates should be considered in the Spacelab design studies [3]. Dose rates for other altitudes and inclinations are given in Reference 4.

TABLE 1. GALACTIC COSMIC RAY DOSE RATES (REM/DAY)

	255 n.m. 55° Incl.	200 n.m. Polar	Geosynchronous
Solar Maximum	0.05	0.07	0.19
Solar Minimum	0.081	0.11	0.29

5.2 Trapped Radiation. The trapped radiation environment will be taken from the most recent data of NASA SP-3024 (currently in six volumes) or from the TRECO computer code available from the National Space Science Data Center, NASA/Goddard Space Flight Center, and merged with trajectory information to find particle fluxes and spectra. The fluxes and spectra will be converted to dose by data and/or computer codes provided by the Aerospace Environment Division, Space Sciences Laboratory, Marshall Space Flight Center (see Section 2.4.2 of NASA TM X-64627).

5.2.1 Near-Earth Environment. The radiation belts trapped near the Earth are approximately azimuthally symmetric, with the exception of the South Atlantic anomaly where the radiation belts reach their lowest altitude. The naturally occurring trapped radiation environment in the anomaly region remains fairly constant with time, although it does fluctuate with solar activity. Electrons will be encountered at low altitudes in the anomaly region as well as in the auroral zones.

5.2.2 Synchronous Orbit Altitude Environment. The trapped proton environment at synchronous orbit altitude is of no direct biological significance but may cause deterioration of material surfaces over long exposure times. The proton flux at this altitude is composed of only low-energy protons (< 4 MeV) and is on the order of 10^5 protons cm^{-2} s^{-1}. The trapped electron environment at synchronous altitude is characterized by variations in particle intensity of several orders of magnitude over periods as short as a few hours. However, for extended synchronous altitude missions, a local time averaged environment can be used. See Section 2.4.2.2 of NASA TM X-64627 for additional data.

5.3 Solar Particle Events. Solar particle events are the emission of charged particles from disturbed regions on the Sun during solar flares. They are composed of energetic protons and alpha particles that occur sporadically and last for several days. The free-space particle event model to be used for Spacelab orbital studies is given in Section 2.4.3.1 of NASA TM X-64627.

6.0 METEOROID

The Spacelab shall be designed for at least a 0.95 probability of no puncture during the maximum total time in orbit using the meteoroid model defined in Section 2.5.1 of NASA TM X-64627.

6.1 Meteoroid Impact. Spacelab meteoroid impact requirements shall be:

Functional Capability. The Spacelab shall provide protection against loss of functional capability of selected critical items when subjected to the meteoroid flux model as defined in NASA TM X-64627. The probability of no penetration shall be assessed on each item dependent upon function criticality.

7.0 ASTRODYNAMIC CONSTANTS

The values given in Sections 1.6 and 2.7 of NASA TM X-64627 shall be used.

REFERENCES

1. Daniels, Glenn E., ed.: Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development, 1973 Revision. NASA TM X-64757, 1973.

2. Smith, R. E., ed.: Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development, 1971 Revision. NASA TM X-64627, 1971.

3. Burrell, M. O., and Wright, J. J.: The Estimation of Galactic Cosmic Ray Penetration and Dose Rates. NASA TN D-6600, March 1972.

4. Watts, J. W., and Wright, J. J.: Charged Particle Radiation Environment for the Spacelab and Other Missions in Low Earth Orbit. NASA TM X-64936, June 1975.

APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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